The value of diagnostic imaging for enhancing primary care in low- and middle-income countries

Vaidehi Nafade,[a,q] Paulami Sen,[a,q] Matthew Arentz,[b] Rigveda Kadam,[b] Jacob Bigio,[c] Luke N. Allen,[d] Dian Maria Blandina,[e,f] Stellah Bosire,[g] Julia Ferreira,[h] Saurabh Jha,[i] Oommen John,[j] S. P. Kalantri,[k] Nkirote Mwirigi,[l] Mamsallah Faal-Omisore,[m] Cesar Ugarte-Gil,[n] Shibu Vijayan,[o] Marie-Claire Wangari,[p] and Madhukar Pai[c,*]

[a]Faculty of Medicine and Health Sciences, McGill University, Quebec, Canada
[b]FIND, Geneva, Switzerland
[c]School of Population and Global Health, McGill University, Quebec, Canada
[d]Department of Primary Care Health Sciences, University of Oxford, Oxford, United Kingdom
[e]People's Health Movement, Jakarta, Indonesia
[f]Laboratory of Primary Health Care, General Medicine and Health Services Research, Aristotle University of Thessaloniki, Thessaloniki, Greece
[g]Africa Center for Health Systems and Gender Justice, Kenya
[h]Harvey E. Beardmore Division of Pediatric Surgery, The Montreal Children's Hospital, McGill University Health Center, Quebec, Canada
[i]Department of Radiology, Hospital of the University of Pennsylvania, Philadelphia, United States
[j]The George Institute for Global Health, New Delhi, India
[k]Mahatma Gandhi Institute of Medical Sciences, Sevagram, India
[l]Ministry of Health, National TB Program, Kenya
[m]Primary Care International, Oxford, United Kingdom
[n]Department of Epidemiology, School of Public and Population Health, University of Texas Medical Branch, Texas, United States
[o]Global Health Practice, Qure.ai, India
[p]Kenya Medical Association, Nairobi, Kenya

Medical imaging is a critical diagnostic modality with diverse applications. Many countries are already using AI-assisted chest x-rays (CXR) for tuberculosis (TB) screening. Point-of-care ultrasound (POCUS) is becoming increasingly accessible, and modeling suggests that its implementation with AI-guided interpretation could prevent infant deaths.[1]

However, there is comparatively little research and advocacy about the value of medical imaging in low- and middle-income countries (LMICs), particularly at the primary care (PC) level. Discussions around diagnostics in global health often focus on laboratory tests: for example, the WHO Essential Diagnostics List (EDL) is exclusively focused on *in vitro* diagnostics (IVDs). There may be a missed opportunity to advocate for and invest in medical imaging, to meet the Sustainable Development Goal objective of universal health care (UHC), which includes primary health care as a core.

Available data suggest that imaging is highly limited at the PC level. The *Lancet* Commission on Diagnostics noted that "diagnostic imaging is essentially absent outside of hospitals."[2] In one multi-country survey, only 2/22 LMICs reported availability of x-ray at the PC level.[3] Another study based on surveys from ten countries estimated that only 1.2% of basic PC facilities and 3.1% of advanced PC facilities had ultrasound. The basic tier includes clinics, pharmacies, and health posts, while advanced facilities refer to health centers with beds, staffed by doctors and nurses.[4]

There are more barriers to the use of imaging as compared to IVDs, particularly access to trained personnel, the cost of equipment and its maintenance, and infrastructure constraints (e.g., space, internet). Still, ongoing inaccessibility is concerning given the medical relevance of imaging.

To understand internationally-accepted indications for imaging, we reviewed 262 WHO disease-specific guidelines published between 2010 and 2023.[5] We found that ultrasound is primarily indicated for pregnancy care while radiography is indicated for respiratory infections, particularly TB, and recent data show that AI outperformed experienced human readers in detecting tuberculosis-related abnormalities.[6] Fig. 1 summarizes these indications.

According to Global Burden of Disease estimates, maternal/neonatal disorders and respiratory infections are among the top five causes of death and disability in low, low-middle, and middle sociodemographic index countries.[7] A recent systematic review also found that respiratory tract infections and pregnancy are among the top ten reasons why patients present to PC.[8]

Beyond WHO guidelines, CXR and ultrasound are used routinely to manage patient care for non-communicable diseases such as trauma, cancer and chronic conditions (e.g., cardiac, hepatic, kidney and

*Corresponding author. Department of Global & Public Health, McGill School of Population and Global Health, McGill University, 2001 McGill College Avenue, Suite 1200, Montreal, QC H3A 1G1, Canada.

E-mail address: madhukar.pai@mcgill.ca (M. Pai).

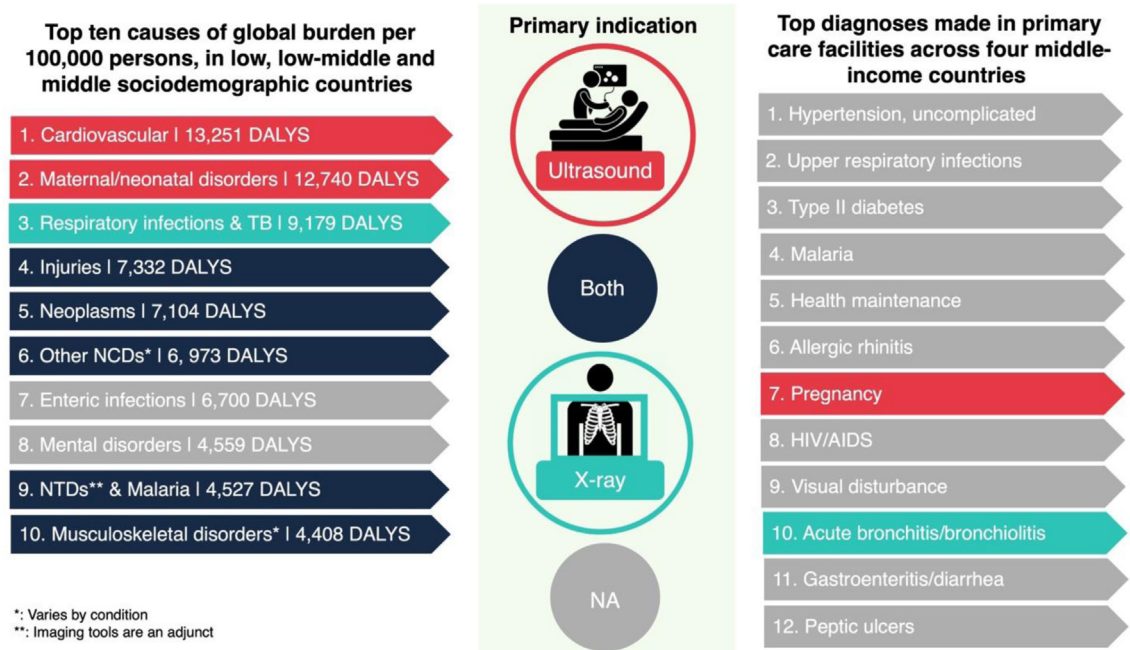[q]Contributed equally as first authors.

Fig. 1: Primary indications for ultrasound and x-ray according to WHO guidelines, mapped to conditions resulting in the largest global burden among low, low-middle, and middle sociodemographic countries and to common diagnoses made in primary care settings across four middle-income countries. DALYs were calculated by summing results from GBD 2019 for low, low-middle, and middle-SDI countries (level 2 causes) obtained from the Institute for Health Metrics and Evaluation's visualization tool: https://vizhub.healthdata.org/. Top diagnoses made in primary care facilities data are derived from Reference.[8]

musculoskeletal disease). While these applications are more typical at the secondary level, there is a growing body of evidence supporting the use of ultrasound in PC.[9] For detecting pneumonia, for example, ultrasound outperforms CXR and provides accuracy that is comparable to CT scans.[10]

To scale up access to imaging at the PC level in LMICs, international stakeholders – health care professionals and their associations, country and regional governments, academia, industry, local and international NGOs—will need to remove policy barriers, train medical experts, invest in evidence generation, increase affordability, and ensure that regulation keeps pace with market expansions while respecting data protection.

We suggest that advanced PC facilities would benefit most from imaging tools. At the basic PC level, health staff without formal certifications can focus on recognizing indications for imaging and referring patients. Given that access to training is a barrier for health care professionals, building this capacity at the advanced PC level will require investment in low-cost, classroom and self-directed longitudinal training. Concurrently, legal barriers to imaging use by non-radiologists should be addressed; for example, in some countries (e.g., India), use of ultrasound is highly regulated due to concerns about prenatal sex selection.

We also need evidence generation tailored to the LMIC context. For example, the optimal density of

imaging technology in a region could be defined based on its population, existing health resources and needs. New evidence on cost-effectiveness (both direct cost savings and reduced health system burden) could guide investment. This, combined with market shaping initiatives such as co-funding or pooled purchasing, will increase affordability and optimize spending.

Among the two imaging modalities, the practicality of ultrasound is clear. Ultrasound is cheaper, safer, and easier to use. It is actively being scaled up as part of maternal and neonatal care and is relatively easy to maintain (but protection from theft is a concern). POCUS is also increasingly designed to suit remote settings, with portable probes that connect to a smartphone or tablet.

However, x-ray remains an essential diagnostic modality, particularly for tuberculosis but also other respiratory conditions, musculoskeletal injuries and disorders, and screening. New, cheaper ultraportable digital x-rays systems are entering the market alongside AI tools (e.g., for TB case finding), but hardware cost remains a barrier.

With both imaging tools, investments will be required for adequate servicing and equipment maintenance (including software/AI updates), and new regulatory frameworks will be needed to enable the secure use of AI and other digital solutions that aim to reduce turnaround time through teleradiology, optimize

communication between health care professionals and with patients, provide learning resources for professionals, enable data collection and more.

In closing, there are promising signs of interest in imaging. The *Lancet* Commission on Diagnostics recommended making "point-of-care ultrasound [available] in primary health-care centres,[2]" and India's inclusion of imaging tools at the primary and community health levels in its national EDL, setting an example for other countries developing their national EDLs. Continued research, investment and regulation is a necessary part of developing robust health systems and attaining UHC.

References
1 Gates M, Gates B. *Imagine a World: where innovations could save the lives of 2 million more mothers and babies.* Bill and Melinda Gates Foundation - Goalkeepers; 2023. https://www.gatesfoundation.org/goalkeepers/downloads/2023-report/2023-goalkeepers-report_en.pdf.
2 Fleming KA, Horton S, Wilson ML, et al. The Lancet Commission on diagnostics: transforming access to diagnostics. *Lancet.* 2021;398(10315):1997–2050.
3 Pande T, Pai M, Khan FA, Denkinger CM. Use of chest radiography in the 22 highest tuberculosis burden countries. *Eur Respir J.* 2015;46(6):1816–1819.
4 Yadav H, Shah D, Sayed S, Horton S, Schroeder LF. Availability of essential diagnostics in ten low-income and middle-income countries: results from national health facility surveys. *Lancet Global Health.* 2021;9(11):e1553–e1560.
5 World Health Organization Publications. https://www.who.int/publications/i?publishingoffices=c09761c0-ab8e-4cfa-9744-99509c4d306b2024.
6 Qin ZZ, Ahmed S, Sarker MS, et al. Tuberculosis detection from chest x-rays for triaging in a high tuberculosis-burden setting: an evaluation of five artificial intelligence algorithms. *Lancet Digital Health.* 2021;3(9):e543–e554.
7 *Institute for health metrics and evaluation global burden of disease data;* 2019. https://vizhub.healthdata.org.
8 Bigio J, MacLean E, Vasquez NA, et al. Most common reasons for primary care visits in low- and middle-income countries: a systematic review. *PLoS Glob Public Health.* 2022;2(5):e0000196.
9 Sorensen B, Hunskaar S. Point-of-care ultrasound in primary care: a systematic review of generalist performed point-of-care ultrasound in unselected populations. *Ultrasound J.* 2019;11(1):31.
10 Mohamed SA, Bazaraa HM, Ishak SK, El-Ghobashy MH, Gommaa MA. The reliability of POCUS in the diagnosis of community-acquired pneumonia in critically ill pediatric patients: a cross-sectional study. *Egypt Pediatr Assoc Gazette.* 2023;71(1):83.